Resource-leveling on a shop floor

T. Sys, D. Van Den Dooren, G. Vanden Berghe, and T. Wauters

KU Leuven, Department of Computer Science, CODeS & iMinds-ITEC
{thomas.sys,david.vandendooren,greet.vandenberghe
tony.wauters}@cs.kuleuven.be

Abstract

In Wycor, a construction company, schedules relating to the shop floor are constructed manually, causing inefficiency and unwanted peak loads. Scheduling is complicated due to precedence of operations, resource constraints (job bound machines), personnel constraints (number of working hours a day, number of employees) and the large number of jobs (over four thousand). The problem at Wycor is a flexible job shop scheduling problem. The main goal of this research is to provide a scheduling support system that simplifies the scheduler's activities and also decreases the peak load at Wycor. A late acceptance algorithm was developed in order to decrease the amount of overtime and scale down the unwanted peak load to an acceptable level.

Keywords: Scheduling, Multi-Mode Resource-Constraint Project Scheduling

Wycor's activities include building, construction and renovation. Most of the necessary constructing materials are produced internally. Therefore, Wycor is in need of a shop floor capable of delivering the required products just in time. Scheduling this shop floor is complex due to precedence of operations, specific constraints and the large number of jobs. The schedules for this shop floor are being constructed manually, causing inefficiency and unwanted peak load, thus increasing the operational costs. The main objective of the identified optimisation problem comprises leveling the peaks to an acceptable level.

In practice, the scheduler now manually constructs a feasible schedule for the jobs. He uses a structure to schedule the jobs in such a way that it is easy for humans to comprehend. The scheduler is very knowledgeable and it was a huge effort to capture sufficient unwritten information for constructing a model based on Wycor's internal structure.

A steepest descent-based algorithm with an improving-or-equal [1] acceptance criterion was used as optimization method. To avoid stagnation in a local optimum, a late acceptance algorithm [2] was implemented. The algorithm decides whether or not to accept a

move by using a list containing the scores of solutions generated during previous iterations. If the current score is better or equal than it was a number of iterations before, the current solution is accepted and its score is stored in the list. Only one parameter needs to be tuned: the length of the list. Beside for its simplicity, late acceptance is favored for its strength: the algorithm adapts itself by changing the values in the list with previous scores, thereby changing the allowed grade of degradation to accept a move.

The Late Acceptance algorithm was extended with a reheating mechanism. Reheating is a particular way of preventing the algorithm from converging; i.e. the list containing previous scores is fully filled with the current score and all the possible moves are explored. Two parameters are applied in the reheating process: the number of iterations executed by the algorithm before reheating takes place and the amount of score increase. The list containing previous scores will be refilled with values that are a certain percentage larger than the original ones.

The developed algorithm provides a partial solution for the scheduling problem within Wycor. Compared to current practice, the optimization approach reduces the objective by approximately one third. The amount of overtime is decreased and the unwanted peak load scaled down to an acceptable level. These results were satisfactory for Wycor. The company intends to start using the algorithm and to further extend the system towards scheduling the engineering and the constuction departments.

References

[1] Jörg Fliege, *Steepest Descent Methods for Multicriteria Optimization.* Mathematical Methods of Operations Research 2000, 51, 3, 479-494.

[2] Edmund K. Burke and Yuri Bykov, *The Late Acceptance Hill-Climbing Heuristic.* Deartment of Computing Science and Mathematics - University of Stirling 2012.